Simulation and Analysis of Energy Consumption of Public Building in Chongqing

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Abstract: Calculation and analysis of energy consumption must be on the base of simulation of building load. DeST is adopted to calculate dynamic cooling load of the main building in Chongqing city. Then water chilling unit's plant capability is checked and energy consumption of the building is calculated. After energy efficiency potency analyzed, optimum running-program is put out and some suggestions are given.

Key words: DeST; annual dynamic load ;energy consumption ;energy efficiency

1 FOREWORD

Different kinds of public buildings have different characteristics of energy consumption. Energy efficiency analysis and suggestions are on the basis of buildings' character. The energy saving can not be realized unless getting hold of its key characteristic.

In order to analyze energy consumption of the main building, the software DeST is used to simulate the annual dynamic load of the main teaching building in Chongqing University. The software is developed by Tinghua University. Thousand illustrations prove the simulation result is believable.

2 GEOMETRIC MODEL OF THE MAIN BUILDING

The main teaching building is seated in Chonqing University along with Jialing River. The building is 26 floors with 5 floors podium .It is composed of offices, classrooms, laboratories and assembly rooms. The model that is set up on the proportion of 1:1 is on the base of plan view drawings. In order to simplify calculation, adjacent rooms with the same function are composed to one big room. The model is given as Fig.1.

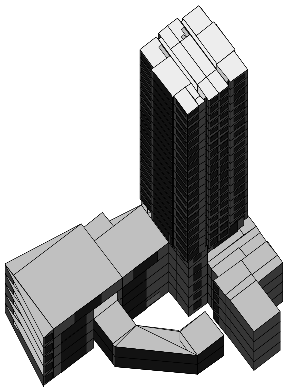

Fig.1 Model of the main building

3 CHECK OF PLANT CAPACITY

Indoor heat production is significant factor of cooling loads in air conditioning system. In order to meet all the need of building, designer always choose water chilling unit in the worst-cast condition. If you want to choose unit neither more nor less than the need, you must simulate load of the building before you design. The maximum indoor heat production should be chosen when you check the water chilling units. As an office building in school, the periodic of the main building is one week and work day differ from weekend. Scheme of equipment and air conditioning system is Tab.1.

The annual dynamic load is shown in Fig 2, from which we can see that the maximums cooling load of the air conditioning is 7977kW. Compared to the primary designed cooling load that is 8900Kw, there is 10.4% margin of the design cooling load. Moreover, the refrigerating capacity is 8975kW, which occupies 88.9% of the refrigeration capacity of the existing refrigerating equipments, and there is 11.1% margin of the existing refrigerating equipments. The maximums hourly load is 170.62W/m^2, which is 85.3% of the design index that is 200W/m^2.

Tab.1 Work and rest scheme

Time	Human 、equipment		Air conditioning system	
	Workday	weekend	Workday	weekend
0~7	0.1	0.1	0	0
8~11:	1	0.3	1	1
12	0.3	0.1	1	1
13~16	1	0.3	1	1
17	0.5	0.25	1	1
18~20	0.1	0.1	1	1
21~22	0.1	0.1	1	1
23	0.1	0.1	0	0

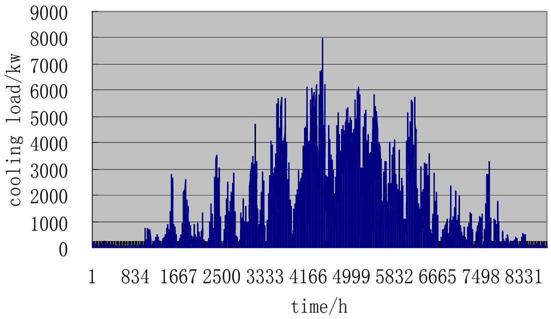

Fig.2 Annual dynamic cooling load

4 CALCULATION OF ENERGY CONSUMPTION

The primary requirement to the indoor heat production for the analysis of energy consumption is to reflect the general level of the building energy consumption, so as to estimate the building energy consumption efficiently and evaluate the energy saving. It is necessary for the analysis of the energy consumption simulation to collect the annual data on the indoor calorific value in different public building and different functional rooms, because of the different heat production in different public building and different functional rooms. The typical indoor heat production should represent the general energy consumption level of its specific building[1] .

The annual air conditioning cooling load is shown in Fig2. The maximums annual cooling load is 7977kW. The space is separated into 10 intervals, and the occupation ratio of cooling load relative to the whole one in each interval is 10%. Then, the average cooling load and the time are summarized in each interval.

From Fig3, we can find that the operating time of the occupancy ratio from 70% to 100% of the maximums cooling load is 47h, and from 60%to 70% is 356h, 50% of the maximums cooling load takes 552h, 40% takes 391h, 30% takes 426h and the load less than 20% of the maximums cooling load takes 802h. The whole running time accounts for 2576h.

Fig.2 shows the tendency of load annual. From the curved we can see the distribution of load: more than 70% of maximum load appears in afternoon of the last ten-day of July and the first ten-day of August;50%~70% of maximum load appears in the morning of the last ten-day of July 、 the first ten-day of August and in the afternoon of last ten-day of June; 40%~50% of maximum load appears in June and September; 30%~40% of maximum load appears in May and the first ten-day of September; less than 20% of maximum load appears in May and October.

There are four water chilling unit working for the building, three centrifugal and one screw water chilling unit. As the load is change with the time, the unit should suit the load as Tab.2.

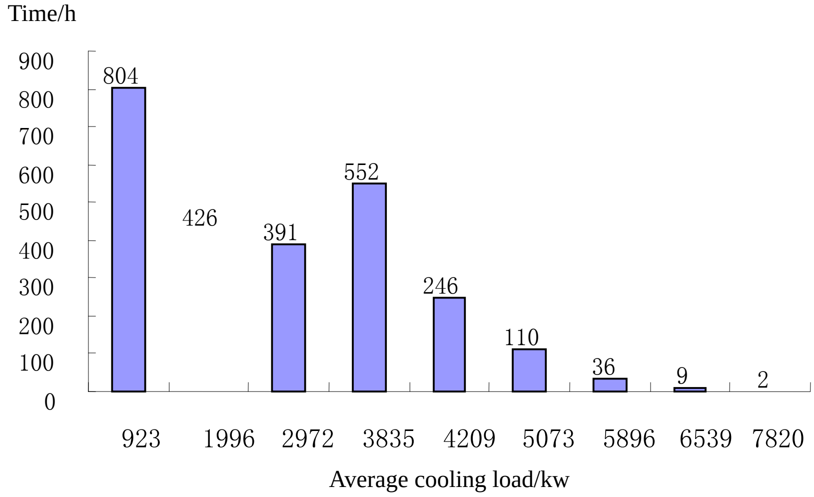

Fig.3 Distribution of cooling load

Tab.2 Operation parameter of water chilling unit

Duty ratio（%）	Run time（h）	max/min cooling load（kw）	Average load（kw）	Units number	Part load（%）
〉70%	36+9+2=47	7977/5580	7820,6539,5896	3large1small	66%~87%
60%~70%	110	5580/4681	5076	2 large 1 small	74%~88%
50%~60%	246	4670/3992	4209	2 large	76%~88%
40%~50%	552	3984/3193	3835	2 large	60%~75%
30%~40%	391	3189/2394	2792	1 large 1 small	65%~86%
15%~30%	668	2391/1206	1779	1 large	47%~91%
5%~15%	272	1193/797	992	1 small	113%~76%
<10%	290	793/357	575	Natural ventilation	

Tab.3 Part load performance of centrifugal water chilling unit （%）

Duty ration of unit	100	90	80	70	60	50	40	30	20	10
Power percent of unit	100	87.0	76.0	65.0	56.0	48.0	40.0	33.0	25.0	21.0

Tab.4 Energy consumption calculation of air conditioning system in summer

Month	Total load（Mwh）	COP	Electricity consumption（Mwh）	Transmission coefficient	Electricity consumption of transmission（Mwh）	Total electricity（Mwh）
May	713.1	5.35	133.29	0.66	87.97	221.26
Jun	1128.49	5.35	210.93	0.66	139.22	350.15
Jul	1477.39	5.35	276.15	0.66	182.26	458.40
Aug	1279.88	5.35	239.23	0.66	157.89	397.12
Sep	818.98	5.35	153.08	0.66	101.03	254.11
Oct	237	5.35	44.30	0.66	29.24	73.54
Total			1056.98		697.61	1754.59

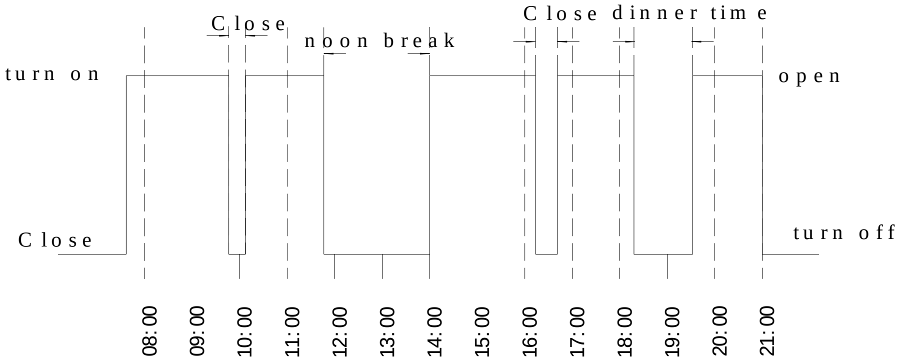

Fig.4 Energy efficiency operation program of water chilling units

Total cold annual has relative with operating characteristic of water chilling unit working in part load. The peculiarity of the centrifugal water chilling unit working in part load is given as Tab.3.[2]

Tab.3 shows that when centrifugal water chilling unit runs in part load between 40%~100%, its efficiency is high. So it is available of the small capacity screw water chilling unit. When the building load is small, the large capacity centrifugal water chilling unit and small screw water chilling unit run together. It can guarantee all the units working in high efficiency range. So the large capacity and small capacity unit work together is not only suit for the main building but for all building.

The energy consumption of the water chilling unit is more than 60% of total energy consumption in air conditioning system. When designing air conditioning system, designer always choose equipment according maximum load. Actually, water chilling unit operates at part load most time. As we know, the energy consumption is low when the machine is working in high efficiency. Therefore, make the water chilling unit operate in high efficiency can save energy.

The energy consumption is equal to product of capacity of units and runtime. Electricity consumption can be reduced by shortening run time. Therefore, optimize working schedule not only can satisfy the people's need for environment but save energy.

Human's load is the most portion of the total load in main building. As there are 30min break in morning and afternoon. The curve look likes dump. We can close the chilling unit to save energy in break and close the units 30min before class over. So the program is set as Fig.6.We can see from Fig.4 that: the unused time of water chilling unit is 30min×2+130min+70min=260min. Compared with 14 hours continued run, this program can save energy 31%. The effect of energy efficiency is visible.

5 SUGGESTIONS

With different work and rest time and different characteristic of cooling load, energy consumption of different public buildings are diverse. So it is very necessary and utility to save energy according detailed building load calculation. There are some suggestions for the main building in Chongqing University as following:

Firstly, run proper cooling unit in different period of load. There are four cooling units in the building, three centrifugal water chilling units and one screw water chilling unit. We can choose different cooling unit to adapt different loads as table4. As a result, the units can be protected with high efficiency and long useful life period.

Secondly, control optimum start-stop time. As the office building in school, the cooling units can be off in rest period and be shutdown half an hour before finish class. It can save 31% energy.

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